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(71) *Sökande* / *Applicant (s)* — *Net Insight AB, Stockholm SE*

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Christina Vängborg

Christina Vängborg

Avgift
Fee 170:-

PATENT- OCH REGISTRERINGSVERKET
SWEDEN

Postadress/Adress
Box 5055
S-102 42 STOCKHOLM

Telefon/Phone
+46 8 782 25 00
Vx 08-782 25 00

Telex
17978
PATOREG S

Telefax
+46 8 666 02 86
08-666 02 86

AWAPATENT AB
Kontor/Handläggare
Stockholm/Stefan Karlsson/SKN

NET INSIGHT AB
Ansökningsnr
Vår referens
SE-2009177

METHODS FOR CONTROLLING RESOURCES IN A COMMUNICATION NETWORK

Technical Field of the Invention

The present invention relates to a method in connection with controlling utilisation of communication resources in a digital time-division multiplexed communication network. More particularly, the present invention relates to the access to time slots in a DTM network.

Background of the Invention

A DTM network (DTM - Dynamic synchronous Transfer Mode) is an example of a circuit switched time-division multiplexed network in which the distribution of access to the bandwidth resources can be dynamically adjusted.

The topology of a DTM network is based upon unidirectional communication on time-division multiplexed bitstreams propagating on optical fibres, each bitstream preferably being accessed by multiple nodes via link interfaces, e.g. in a bus or ring structure. The bandwidth of each wavelength is divided into 125 µs frames, which in turn are divided into 64-bit time slots. In a system of this kind, write access to time slots is typically distributed among the link interfaces connected to said bitstream. A link interface will thus typically have write access to a number of the time slots, i.e. to a specific set of slot position within each recurring frame, and may thereby use these time slots for transmission. It may thus only use a time slots for transmission if it has write access to this specific slot position.

The distribution of write access to time slots among the link interfaces may typically be changed when so desired or required. For example, write access to a slot

may, if so requested or desired, be transferred from one link interface, typically having access to a surplus of time slots or serving less prioritised applications, to another link interface that for some reason is in need of transfer capacity.

In an example of such a system, wherein the feature of write access to time slots is accompanied by a feature of time slot ownership, a first link interface that owns a time slot may, if so desired or required, temporarily lend the write access to that time slot to a second link interface that for some reason requires more capacity. In such a case, the second link interface borrowing the time slot will temporarily have the write access to the time slot, but will typically, at some point in time, return write access to the slot to the owner of the slot, i.e. to the first link interface. In order to ensure that there is no conflict in the distribution of write access to a lent time slot, the first link interface, which is the owner of the lent time slot, needs to determine whether any other link interface has write access to the lent time slot.

As an example of such a system, WO9736402 discloses a method in a communication network of the aforementioned kind, in which the degree of temporary allocation of slots is evaluated, and in which, responsive to the evaluation of temporary allocation, the number of slots being owned by the link interfaces is modified accordingly. That is, the ownership of a slot is transferred from one link interface to another based on the degree of borrowing of slots.

A problem related to these kind of networks is to ensure that the distribution of write access to time slots is conflict free, i.e. that no two or more link interfaces regard themselves as having write access to the same slot position, also when there are alterations in the network.

Summary of the Invention

It is an object of the invention to provide a solution to the above mentioned and to other problems, and to provide a scheme that simplifies the way in which a conflict free distribution of access to resources in the network is ensured when there are alterations in the network.

This object is achieved by the invention as set forth in the accompanying claims.

The invention pertains to a network comprising communication links that transports data in time slots, wherein access to the time slots is distributed among interfaces to each of the communication links. For a communication link, a state of access to a set of one or more time slots is determined for each interface of the interfaces to the communication link by sending an inquiry from the interface to all other interfaces to the communication link that the interface is aware of, and receiving, at the interface, replies to said inquiry from all other interfaces. The inquiry and the replies are related to whether or not any one of all other interfaces consider itself as currently having access to any one of the set of time slots. Furthermore, an interface will determine itself as not having access if no reply is received from one of all other interfaces.

The invention is based on the recognition that in a network of the kind described above, the feature that an interface will determine itself as not having access if no reply is received from one of all other interfaces, may be used to ensure a conflict free distribution of access to resources in the network also after alterations in the network. Thus, in the case of an alteration in the network that may give rise to a risk of conflicts in the distribution of access to resources on a communication link, one interface of the interfaces connected to the communication link will determine that there is a risk of conflict in the distribution of access to resources and

as a result of this refrain from sending replies to inquiries indicating that it does not consider itself to have access to a time slot. By doing this, no inquiry that is sent on the communication link will result in an interface considering itself to have access to a set of one or more time slots to which the inquiry refers, since one interface will not send a reply. Thus, as soon as one link interface of the interfaces connected to the link becomes aware of the risk of conflicts, the other interfaces will become indirectly aware of it since the node will not respond to inquiries. This is very advantageous compared to the alternative where a warning message is sent from the interface that becomes aware of the risk of conflicts, since such warning message will always run the risk of not reaching all of its intended recipients. Furthermore, the method according to the invention provides a quick response to a change in the network since it will prevent any interfaces from consider itself to have access to a set of one or more time slots after sending an inquiry regarding the set of one or more time slots as soon as the first link interface determines that there is a risk of conflict in the distribution of access to resources on the link. Thus, the method according to the invention ensures that a situation where there is a risk of conflicts in the distribution of access to time slots is recognised and dealt with fast so that the situation where two interfaces consider themselves to have access to the same time is prevented. Furthermore, the use of the idea that no reply is a negative reply makes the method insensitive to loss of messages and thus reliable in a network where there are alterations.

Note that it is only necessary that an interface refrains from sending any reply indicating that it does not have access to the set of one or more time slots after it has determined that there is a risk of conflicts in the distribution of access to resources. Thus, the

interface might still send replies indicating that it has access to the set of one or more time slots. In fact, the interface might send such replies to all inquiries regardless of the actual state of the set of one or more time slots in the interface. However, the interface preferably refrains from sending replies altogether after determining that there is a risk of conflicts in the distribution of access to resources. Similarly, the interface will preferably stop sending inquiries after determining that there is a risk of conflicts in the distribution of access to resources. As an alternative the interface will continue sending inquiries but discard all replies to the inquiries. According to a first embodiment of the invention, a method for controlling the resources on a communication link in a network of the kind described above is provided. According to the first embodiment, the alteration in the network that may give rise to a risk of conflicts in the distribution of access to resources on a communication link is a change of which interfaces are connected to the communication link. Thus, a method according to the first embodiment of the invention comprises the reception, in one interface of the interfaces that are connected to the communication link, of a link change message indicating a change of which interfaces are connected to the communication link. Furthermore, after the reception of the link change message, said one interface will refrain from sending replies.

Furthermore, the method according to the invention preferably comprises the determining at said one interface of the interfaces to the communication link that there is no longer a risk of conflict between interfaces of the access to time slots. As a result of this said one interface will resume sending replies. In the first embodiment the determining that there is no longer a risk of conflict is preferably done after the reception in said one interface of a message from an

other interface, the message indicating that the other interface has the same view of which interfaces are connected to the communication link as said one interface. Thus, not until all interfaces have the same view of which interfaces are connected to the communication link, will all interfaces have resumed sending replies.

According to a second embodiment of the invention, a method for controlling the resources on a communication link in a network of the kind described above is provided. According to the second embodiment, the alteration in the network that may give rise to a risk of conflicts in the distribution of access to resources on a communication link is a change of ownership of time slots on said communication link. Thus, a method according to the second embodiment of the invention comprises the reception, in one interface of the interfaces to the communication link, of a request of a change of ownership of time slots on said communication link. Furthermore, after the reception of the request of a change of ownership of time slots on said communication link, said one interface will refrain from sending replies.

Brief Description of the Drawings

Exemplifying embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Fig. 1a illustrates an exemplary network of the kind addressed by the invention;

Fig. 1b illustrates an exemplary frame structure used in the network of Fig. 1a;

Figs. 2 and 3 are schematic signalling diagrams illustrating probe-message incorporating processes according to embodiments of the invention; and

Figs. 4a and 4b show state transitions according to embodiments of the invention;

Fig. 5 is a schematic signalling diagram illustrating probe-message incorporating processes according to a first embodiment of the invention;

Fig. 6 is a schematic signalling diagram illustrating link synchronisation message incorporating processes according to the first embodiment of the invention;

Fig. 7 is a schematic signalling diagram illustrating probe-message incorporating processes according to a second embodiment of the invention; and

Fig. 8 is a schematic signalling diagram illustrating link synchronisation message incorporating processes according to the second embodiment of the invention.

Detailed Description of Preferred Embodiments

An exemplary communication network NW of the kind addressed by the invention is shown in Fig. 1a and comprises a plurality of nodes N that each is connected to a single-ring link L via one or more link interfaces I. On the link L, a recurrent, essentially fixed size frame of the kind illustrated in Fig. 1b is transported uni-directionally. In the exemplified network, each frame has a nominal duration of 125 μs and is divided into a plurality of 64-bit time slots. The start of each frame is identified by a so-called synchronisation slot S, and the end of each frame is provided with so-called guard band slots G included to accommodate for small jitters in the network frame frequency. The remaining slots of the frame are control and data slots used for transporting control signalling and payload data, respectively, between the link interfaces I connected to the link L. Write access to the control and data slots are distributed, and may at any time be re-distributed as desired, among the interfaces I connected to the link L.

In the following figures, it is assumed that changes in the distribution of write access to slots as well as

ownership of time slots is handled by control messages sent and received by the link interfaces of the network, and that said messages include Resource Transfer (RES_TR) messages, Ownership Change (OWN_CH) messages, Probe (PR) messages, Probe Reply (PR_REP) messages, and Link Synchronisation (LK_SYNC) messages, said massages having the following characteristics:

A Resource Transfer (RES_TR) is used when a link interface transfers the write access to a slot to another link interface. It is a unicasted message that is sent from the former link interface to the latter link interface and identifies the slot (or slots) for which write access is transferred.

An Ownership Change (OWN_CH) message is used by a master interface on the link (for example being appointed as the link interface having the lowest link layer address) to inform the link interfaces connected to the link of changes in the distribution of slot ownership. It is a broadcasted message that is sent from the master interface to all link interfaces connected to the same link and identifies which interface that is the owner of which slots. (Note that the owner of a slot need not in this example necessarily have the write access to the slot, as the write access to the slot may have been borrowed by another link interface).

A Probe (PR) message is used when a link interface wants to investigate the write access situation with respect to a specific time slot. It is a broadcasted message that is sent from the investigating link interface to all other link interfaces on the same link and identifies the slot (or slots) that the inquiry pertains to.

A Probe Reply (PR_REP) message is used by each link interface as the reply to a received Probe message. It is a unicasted message that shall be sent, from each link interface that has received a Probe Message, to the link interface that was the sender of that Probe Message. It

identifies whether or not the link interface sending the Probe Reply message considers itself as having write access to the slot (or slots) that the Probe Message pertained to.

A Link Synchronisation (LK_SYNC) message is initiated by a master interface on the link (for example being appointed as the link interface having the lowest link layer address) when the master interface receives a message indicating a different set of link interfaces connected to the link than the current view of the master interface. It is a unicasted message that is sent from a link interface to a next link interface connected to the same link (for example the link interface having the closest higher link layer address). The Link Synchronisation (LK_SYN) comprises a list of the interfaces connected to the link together with a respective scalar corresponding to the number of time slots the link interface requests on the link. As long as the link interfaces in the list of the Link Synchronisation (LK_SYNC) message matches a link interface' current view of which link interfaces are connected to the link, the Link Synchronisation (LK_SYNC) message will be forwarded to a next link interface. However, if the link interfaces in the list of the Link Synchronisation (LK_SYNC) message does not match a link interface' current view of which link interfaces are connected to the link, the Link Synchronisation (LK_SYNC) message will be discarded and thus not be forwarded to a next link interface.

As a background of the use of probe-messages, message procedures incorporating probe-message features will now be described with reference to the signalling diagrams of Figs. 2 and 3. For simplicity, it is assumed in Figs. 2 and 3 that only three link interfaces A, B, and C are connected to the link of interest, and that the link interface C has been appointed master interface on this link, which in these examples means that link

interface C controls the distribution of slot ownership on the link. Also, note that time flow from top to bottom in Figs. 2 and 3.

In Fig. 2, as a result of link interface B having announced a need for write access to more slots (typically including one or more messages not illustrated in Fig. 2), link interface A transfers write access to a set of the slots that it is the owner of to the link interface B by sending a Resource Transfer (RES_TR) message 10 to the link interface B. Note that link interface B in this embodiment does not send any acknowledgement on this transfer to the link interface A.

At repeated intervals, the link interface A will instead "probe" all slots that it is the owner of and that it has lent to other link interfaces to make sure that they are actually in use by the other link interfaces and not have been "lost" in the system. Consequently, after a certain time, the link interface A will send a Probe (PR) message 11 pertaining to the set of slots borrowed by the link interface B to all link interfaces on the link. In reply to the Probe message 11, the link interfaces B and C will send Probe Reply (PR_REP) messages 12 and 13, respectively, to the link interface A. If both Probe Reply messages 12 and 13 are received by the link interface A and indicate that neither the link interface B nor the link interface C consider itself as having write access to the subject set of slots (meaning that the write access to the slots in fact were "lost" in the system), the link interface A is allowed to determine that it has the write access to the set of slots and that the set of slots shall no longer be considered lent to another link interface. However, in all other situations, i.e. if any one of the link interface B or the link interface C fails to reply to the probe message, if the reply from any one of the link interfaces B or C fails to reach the link interface A, or if any one of the replies received by the link interface

A indicates that any one of the link interface B or the link interface C considers itself as having write access to the set of slots, link interface A will continue to consider the set of slots as still being lent to another link interface.

Consequently, according to this example the link interface A will stop the repeated probing the subject set of slots as a result of the link interface B returning the set of slots to the link interface A, the link interface C (being the master interface) deciding upon a new distribution of slot ownership that no longer makes the link interface A the owner of the set of slots and thus no longer makes the link interface A the "lender" that is obliged to probe the set of slots, or as a result of a probe message exchange causing the link interface A to determine that no other link interface on the link has the write access to the subject set of slots.

Fig. 3 shows an example of a process for distributing ownership of slots to the link interfaces. In the exemplified procedure, the master interface informs all link interfaces on the link, of which link interfaces owns which slots, using an Ownership Change (OWN_CH) message 20 that is broadcasted to all link interfaces. However, to make sure that no link interface has misinterpreted the ownership change, perhaps by not having received the Ownership Change message 20, in a way that may risk two or more link interfaces regarding themselves as both having write access to the same slot, a link interface will not immediately start using a new slot that it has been given ownership of or access to according to the ownership change message, but will at first regard the so-received slot as being lent, or at least as having an uncertain write access status. The link interface will therefore send a probe message to make sure that no other link interface on the link regards itself as having write access to the slot or as

being the owner of the slot, in similar to what has been described above with reference to Fig. 2. Only after having verified so will the link interface conclude that it may consider itself as having write access to the slot and may therefore start to use the slot for transmission (or for example lend it to another link interface).

This is illustrated in Fig. 3 at 21, wherein the link interface A sends a Probe (PR) message to the link interfaces B and C, which respond by sending Probe Reply (PR_REP) messages back to the link interface A. Similarly, as illustrated in Fig. 3 as probing session 22, the link interface B verifies that the access to the new slots that it has been given ownership of according to the Ownership Change message 20 is conflict free by sending a similar Probe (PR) message to the link interfaces A and C and receiving similar replies from the link interfaces A and C. At 23, a similar probing session is initiated by the link interface C for the link interface C to verify the conflict free access to the slots that it has been given ownership of by the Ownership Change message 20.

It shall be understood that the probing sessions 21, 22 and 23 with respect to the link interface A, B and C, respectively, have been illustrated as taking place after each other in Fig. 3 to simplify description, and that they may, and normally will, be performed more or less at the same time and will thus overlap each other in time.

The above described process is advantageously be used for verifying a conflict free write access situation in the context of any ownership change, i.e. during ongoing operation as well as the change represented by a link startup/restart.

For a further background of the use of probe-messages, Figs. 4a and 4b illustrate exemplifying transitions between states at the link interface A in accordance with the procedures that have been described in Fig. 2 and 3, respectively. In these figures, each

slot is by the link interface A considered to be in one of several states including, however not being limited to, the following states:

FREE, wherein the slot is owned by the link interface A and is available for immediate use by the link interface A;

LENT, wherein the slot is owned by the link interface A, but write access thereto is temporarily lent to another link interface;

PROBE, wherein the link interface A has initiated a probing procedure with respect to the slot; and

LOST, wherein the slot is neither owned nor used by the link interface A.

In Fig. 4a, it is initially assumed that the link interface A owns the slot and that it considers the slot to be in the FREE state. As a result of the link interface B being in need of more transfer capacity, the link interface A lends the slot to the link interface B, cf. Fig. 2, whereby the state of the slot goes to the LENT state (transition 1) as far as the link interface A is concerned. As mentioned above, the link interface A will in this embodiment repeatedly probe all slots that is has in the LENT state to make sure that they are actually in use by other link interfaces and has not been "lost" in the system. Hence, after a period of time, the link interface A will start a probing session with respect to the subject slot and will during the probing session regard the slot as being in the PROBE state (transition 2). If outcome of the probing session is that no other link interface on the link claims any access to the slot, link interface A will consider the slot as once again being in the FREE state (transition 3a). However, in all other cases, e.g. if the slot is in use by another link interface or if there is any uncertainty as to the access status of the slot, the link interface A will for now continue to regard the link interface as being in the LENT state (transition 3b). Also, to exemplify a third

possible transition from the PROBE state, if the link interface A receives an ownership change message that indicates that the slot, while being in the PROBE state, is no longer owned by the link interface A, the link interface A will consider the slot as being LOST (transition 3c).

In Fig. 4b, it is initially assumed that the link interface A is not an owner, nor a user of the slot, and the slot is thus as far as the link interface A is concerned regarded as being in the LOST state. It is then assumed that the link interface A receives an ownership change message that indicates that the subject slot is now to be owned by the link interface A, cf. Fig. 3. For reasons similar to what has been described with reference to Fig. 3, the link interface A will then at first regard the slot as being in the LENT state (transition 4). It will then start a probing session (transition 2) to verify the write access status with respect to the slot, said probing session having the same possible outcomes (transitions 3a, 3b and 3c) as has been described above with reference to Fig. 4a.

Message procedures incorporating probe-message features and link synchronisation message features according to a first embodiment of the invention will now be described with reference to Figs 5 and 6. For simplicity, it is assumed that there are only three link interfaces A, B, and C connected to the link of interest, and that the link interface C has been appointed master interface on this link, which in these examples means that the link interface C controls the link synchronisation and the distribution of slot ownership. Also, note that time flow from top to bottom in Figs 5 and 6.

In Fig. 5 procedures incorporating probe-message features according to a first embodiment of the invention are shown. The link interface A has given write access to a set of time slots that it is the owner of to the link

interface B. Thus, at repeated intervals, the link interface A will "probe" all slots that it is the owner of and that it has lent to other link interfaces to make sure that they are actually in use by the other link interfaces and not have been "lost" in the system. This is illustrated at 51 in Fig. 5 and is done in accordance with the procedure described with reference to Fig. 2.

At a first point in time T1 in Fig. 5 the link interface B receives a link change message saying that the link has changed, i.e. that one or more new link interfaces has been added to the link, one or more old link interfaces has been removed from the link or both. In this example the change is the addition of a link interface D to the link of interest. When this link change message is received, the link interface B will disable its probe. This means that link the link interface B will 1) discard any incoming Probe (PR) messages, 2) discard any incoming Probe Reply (PR_REP) messages, 3) stop sending Probe Reply (PR_REP) to incomming Probe (PR) messages, 4) stop sending Probe (PR) messages, and 5) regard all time slots for which the state is PROBE as LENT. Thus, after the first point in time T1 a Probe (PR) message from the link interface A to the link interface B will not result in a Probe Reply (PR_REP) message from the link interface B to the link interface A. This is illustrated in Fig. 5 at 52.

As mentioned above with reference to Fig. 3, a link interface will not consider itself to have access to a set of slots that it owns and that it has lent if any one of the link interface on the link fails to reply to a Probe (PR) message from the link interface that owns the set of slots. Thus, in the case illustrated at 52 in Fig. 5, the link interface A will not consider itself as having write access to any of the slots it is the owner of and that it has lent to other link interfaces, since the link interface A will not receive any Probe Reply (PR_REP) message from the link interface B.

Since all link interfaces A, B, and C are connected to the same link, the link interfaces A and C will also receive a link change message. Thus, after a second point in time T2, the link interface C will also receive the message saying that the link has changed and stop sending Probe Reply (PR_REP) messages. This is illustrated at 53 in Fig. 5. Finally after a third point in time T3, the link interface A will also receive the link change message and stop sending Probe (PR) messages. This is illustrated at 54 in Fig. 5. The link change message will also indicate the link interfaces connected to the link after the change. Similarly, each link interface will have a list of the link interfaces connected to the link. After the reception of a link change message a link interface will update its list of link interfaces connected to the link.

Note that, when a link change message is received in a link interface, the probe could be disabled at all link interfaces of the node that the link interface is arranged in. A reason to do this is that a link change message on one link, indicates a higher possibility of changes elsewhere in the network.

Turning now to Fig. 6, procedures incorporating link synchronisation features according to the first embodiment of the invention are shown. At the second point in time T2, when the link change message reaches the master interface C, the master interface will send a Link Synchronisation (LK_SYNC) message to the next link interface B. This starts a link synchronisation message procedure indicated at 61 in Fig. 6. The Link Synchronisation (LK_SYNC) message will comprise a list of the interfaces connected to the link, an thus indicate that a new link interface D has been added to the link in addition to the link interfaces A, B, and C. Furthermore, for each link interface in the list the Link Synchronisation (LK_SYNC) message will comprise a scalar indicating the requested number of time slots of that

link interface. When the Link Synchronisation (LK_SYNC) message is received at the next link interface B, this link interface will determine if the link interfaces in the list of the Link Synchronisation (LK_SYNC) message matches its own list of link interfaces. Since the link interface B has received the link change message at the first point in time T1 it will have updated its list so that it will be the same as the one of the Link Synchronisation (LK_SYNC) message. Thus, the link interface B will forward the Link Synchronisation (LK_SYNC) message to the next link interface A on the link and this link interface A will determine if the list of link interfaces of the Link Synchronisation (LK_SYNC) message matches its own list of link interfaces. Since the link interface A has not yet received the link change message at the second point in time T2 its list of link interfaces will not be the same as the one of the Link Synchronisation (LK_SYNC) message. Thus, the link interface A will not forward the Link Synchronisation (LK_SYNC) message.

Having sent a Link Synchronisation (LK_SYNC) message the master interface expects to receive it back. If it does not, the master interface will re-send the Link Synchronisation (LK_SYNC) message after a predetermined time period. Thus, in this example, after the predetermined period of time the master interface C will re-send the Link Synchronisation (LK_SYNC) message. This is indicated at 62 in Fig. 6. Analogous with the description above, the Link Synchronisation (LK_SYNC) message will reach the link interface A. However, in this case the Link Synchronisation (LK_SYNC) message reaches the link interface after the third point in time T3. Thus, the link change message will have reached also the link interface A. Thus, the list of link interfaces of the Link Synchronisation (LK_SYNC) message will match the list of link interfaces of the link interface A. The link interface A will then forward the Link Synchronisation

(LK_SYNC) message to the link interface D. In this case, the list of link interfaces of the Link Synchronisation (LK_SYNC) message matches the list of link interfaces of the link interface D, and the Link Synchronisation (LK_SYNC) message will be forwarded to a the master interface. Having received the Link Synchronisation (LK_SYNC) message the master interface can conclude that all link interfaces connected to the link have the same view of which link interfaces are connected to the link. Thus the probe of the master link interface can be enabled again.

Note that the probe of each of the other link interfaces A, B, and D will be enabled as soon as it receives a Link Synchronisation (LK_SYNC) message that comprises a list of link interfaces that matches its own list of link interfaces. However, this does not change the fact that no probe session will result in a link interface concluding that it has write access to a time slot to which the probe session pertains, until the master interface enables its probe. This is done when all interfaces connected to the link have the same view of which link interfaces are connected to the link, i.e. when the master interface will receive the Link Synchronisation (LK_SYNC) message back from the link interface D.

Message procedures incorporating probe-message features and link synchronisation message features according to a second embodiment of the invention will now be described with reference to Figs 7 and 8. For simplicity, it is assumed that there are only three link interfaces A, B, and C connected to the link of interest, and that the link interface C has been appointed master interface on this link, which in these examples means that the link interface C controls the link synchronisation and the distribution of slot ownership. Also, note that time flow from top to bottom in Figs 7 and 8.

In Fig. 7 procedures incorporating probe-message features according to a second embodiment of the invention are shown. The link interface A has given write access to a set of time slots that it is the owner of to the link interface B. Thus, at repeated intervals, the link interface A will "probe" all slots that it is the owner of and that it has lent to other link interfaces to make sure that they are actually in use by the other link interfaces and not have been "lost" in the system. This is illustrated at 71 in Fig. 7 and is done in accordance with the procedure described with reference to Fig. 2.

At a fourth point in time T4 in Fig. 7 the link interface B sends a message to the master interface C, saying that it wants to change its ownership of time slots, i.e. that it wants to have ownership of one or more new time slots or one or more less time slots. When this message is received at the master interface C at a fifth point in time T5 in Fig. 7, the master interface C will disable its probe. This means that the master interface C will 1) disregard any incoming Probe (PR) messages, 2) disregard any incoming Probe Reply (PR_REP) messages, 3) stop sending Probe Reply (PR_REP) to incomming Probe (PR) messages, 4) stop sending Probe (PR) messages, and 5) regard all time slots for which the state is PROBE as LENT. Thus, after the second point in time T2 a Probe (PR) message from the link interface A to the master interface C will not result in a Probe Reply (PR_REP) message from the master interface C to the link interface A. This is illustrated in Fig. 7 at 73.

As mentioned above with reference to Fig. 3, a link interface will not consider itself to have access to a set of slots that it owns and that it has lent if any one of the link interface on the link fails to reply to a Probe (PR) message from the link interface that owns the set of slots. Thus, in the case illustrated at 73 in Fig. 7, the link interface A will not consider itself as having write access to any of the slots it is the owner

of and that it has lent to other link interfaces, since the link interface A will not receive any Probe Reply (PR_REP) message from the master interface C.

Turning now to Fig. 8, procedures incorporating link synchronisation message features according to the second embodiment of the invention are shown. At the fifth point in time T5, when the message regarding a request of ownership change from the link interface B reaches the master interface C, the master interface will send a Link Synchronisation (LK_SYNC) message to the next link interface B. This starts a link synchronisation message procedure indicated at 81 in Fig. 8. Link Synchronisation (LK_SYNC) message will indicate a new distribution of requested ownership of slots between the link interfaces A, B, and C. This is done by the list of link interfaces in the Link Synchronisation (LK_SYNC) message. As mentioned above each link interface in the list has a corresponding scalar indicating a requested number of time slots on the link. When a Link Synchronisation (LK_SYNC) message is received at a link interface it will determine the time slots that it will own from this list of link interfaces and the corresponding scalars. For example, the number of time slots may be distributed so that each link interface will get a percentage of the time slots on the link that is equal to the percentage of the total number of requested time slots. For example, given 2000 time slots on a link in each frame and a request of 1000 time slots from the link interface A, 2000 time slots from the link interface B and 1000 time slots from the link interface C. This will give the link interface A 50% of the 2000 time slots, i.e. 1000 time slots, and the link interfaces B and C 25% of the time slots each, i.e. 500 time slots each. The distribution could then be such that link interface C will get the first 500 time slots, the link interface B the following 500 time slots, and the finally the link interface A the last 1000 time slots in each frame.

Since, in this example no changes have been done of the link interfaces connected to the link, the Link Synchronisation message will be forwarded from each of the link interfaces and sent back from the link interface A to the master interface C. Thus, when the Link Synchronisation (LK_SYNC) message is received at the master interface, the probe of the master link interface can be enabled again.

Although the invention has been exemplified above using embodiments wherein the probing feature according to the invention is used primarily for making sure that write access to a slot has not been "lost" in the system, the invention may of course just as well to make sure that nothing has caused two link interfaces to consider themselves as both being the owner of or having write access to the same slot. For example, a link interface could use the invention to verify the conflict free status of all time slots that it considers as being FREE, i.e. that is meant to be available for immediate use by the link interface.

Moreover, even though the invention has been exemplified above using embodiments wherein the probing feature according to the invention is used primarily for verifying or monitoring a conflict free write access situation, and/or a conflict free slot ownership distribution, both being preferred uses, it may just as well be used to verify any other type of slot/token access status.

Also, even though the invention has been described using embodiment wherein the probing feature of the invention is used with respect to access to one or more time slots, it may advantageously be used to in systems wherein access to a slot or set of slots may be limited to a portion of a link, thereby making it possible for two or more link interfaces to use the time slot on separate portions of the link. The inquiries and replies related to a probing session according to the invention

would then preferably include optional information on which portion of a link over which a link interface considers itself to have write access to the subject slot (or slots).

As is understood, many different alterations and modifications with respect to embodiments described above, as realised by those skilled in the art, may be made within the scope of the invention, which is defined by the accompanying claims.

CLAIMS

1. A method for controlling the resources on a communication link that transports data in time slots, wherein access to said time slots is distributed among interfaces to said communication link, and wherein a state of access to a set of one or more time slots is determined for each interface of said interfaces to said communication link by sending an inquiry from the interface to all other interfaces to said communication link that the interface is aware of, and receiving, at the interface, replies to said inquiry from said all other interfaces, said inquiry and said replies being related to whether or not any one of said all other interfaces consider itself as currently having access to any one of said set of time slots, and wherein each interface of said interfaces will determine itself as not having access to any one of said set of time slots if no reply is received from one of said all other interfaces, comprising the steps of:

determining at one interface of said interfaces to said communication link that there is a risk of conflict between interfaces of the access to time slots;

refraining from sending replies indicating that said one interface does not have access to any one of said set of time slots from said one interface after the determination of a risk of conflict between interfaces of the access to time slots.

2. The method according to claim 1, wherein the step of refraining comprises the step of:

refraining from sending replies from said one interface after the determination of a risk of conflict between interfaces of the access to time slots.

3. The method according to claim 2, further comprising the step of:

refraining from sending inquiries from said one interface after the determination of a risk of conflict between interfaces of the access to time slots.

4. The method according to claim 2, further comprising the step of:

discarding all replies received at said one interface after the determination of a risk of conflict between interfaces of the access to time slots.

5. The method according to claim 2, further comprising the steps of:

determining at said one interface of said interfaces to said communication link that there is no longer a risk of conflict between interfaces of the access to time slots;

resuming the sending of replies from said one interface after the determination that there is no longer a risk of conflict between interfaces of the access to time slots.

6. The method according to claim 3, further comprising the steps of:

determining at said one interface of said interfaces to said communication link that there is no longer a risk of conflict between interfaces of the access to time slots;

resuming the sending of replies from said one interface after the determination that there is no longer a risk of conflict between interfaces of the access to time slots

resuming the sending of inquiries from said one interface after the determination that there is no longer a risk of conflict between interfaces of the access to time slots.

7. The method according to any one of claim 1-4, further comprising the step of:

receiving at one interface of said interfaces to said communication link a link change message indicating a change of said communication link, and

wherein the step of determining that there is a risk of conflict between interfaces of the access to time slots is done as a result of the reception of said link change message.

8. The method according to claim 7, wherein each of said interfaces to said communication link comprises a list of interfaces connected to said communication link, and wherein said link change message comprises an updated list of interfaces connected to said communication link, further comprising the steps of:

updating, at the reception of said link change message, the list of interfaces connected to said communication link in said one interface in accordance with said updated list of interfaces connected to said communication link.

9. The method according to claim 8, further comprising the step of:

receiving at said one interface of said interfaces to said communication link a link synchronisation message from another interface indicating that the list of interfaces of said other interface is equal to the list of interfaces of said one interface, and

determining, as a result of the reception of said link synchronisation message, at said one interface of said interfaces to said communication link that there is no longer a risk of conflict between interfaces of the access to time slots;

resuming the sending of replies from said one interface after the determination that there is no longer

a risk of conflict between interfaces of the access to time slots.

10. The method according to any one of claim 1-4, further comprising the step of:

receiving at one interface of said interfaces to said communication link an ownership request message requesting a change of the distribution of ownership of time slots on said communication link, and

wherein the step of determining that there is a risk of conflict between interfaces of the access to time slots is done as a result of the reception of said ownership request message.

11. A method for controlling the resources on a communication link that transports data in time slots, wherein access to said time slots is distributed among interfaces to said communication link, comprising the steps of:

sending an inquiry from a first interface to said communication link to a set of interfaces to said communication link;

determining at one interface of said set of interfaces that there is a risk of conflict between interfaces of the access to time slots; and

refraining, as a result of the determining step, from sending replies indicating that said one interface does not have access to any one of said set of time slots from said one interface.

12. The method according to claim 11, further comprising the step of:

said interface determining itself as not having access to any one of said set of time slots if no reply is received from one of said set of interfaces.

ABSTRACT

A method for controlling the resources on a communication link that transports data in time slots is disclosed. Access to time slots is distributed among interfaces to said communication link and a state of access to a set time slots is determined by sending an inquiry from an interface to all other interfaces, and receiving, at the interface, replies to the inquiry from the other interfaces. The interface will determine itself as not having access to any one of said set of time slots if no reply is received from one of the other interfaces. According to the method, it is determined at one interface that there is a risk of conflict between interfaces of the access to time slots. As a result of this the interface will refrain from sending replies that indicates that the interface does not have access to the set of time slots from said one interface.

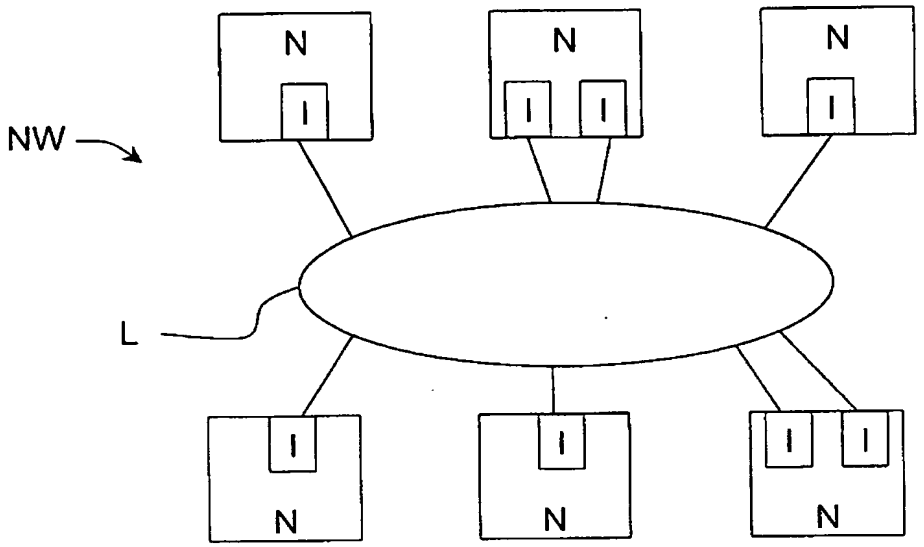


FIG. 1a

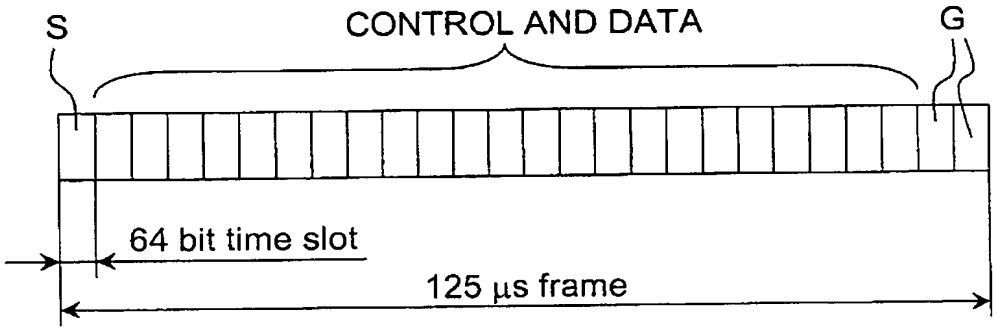


FIG. 1b

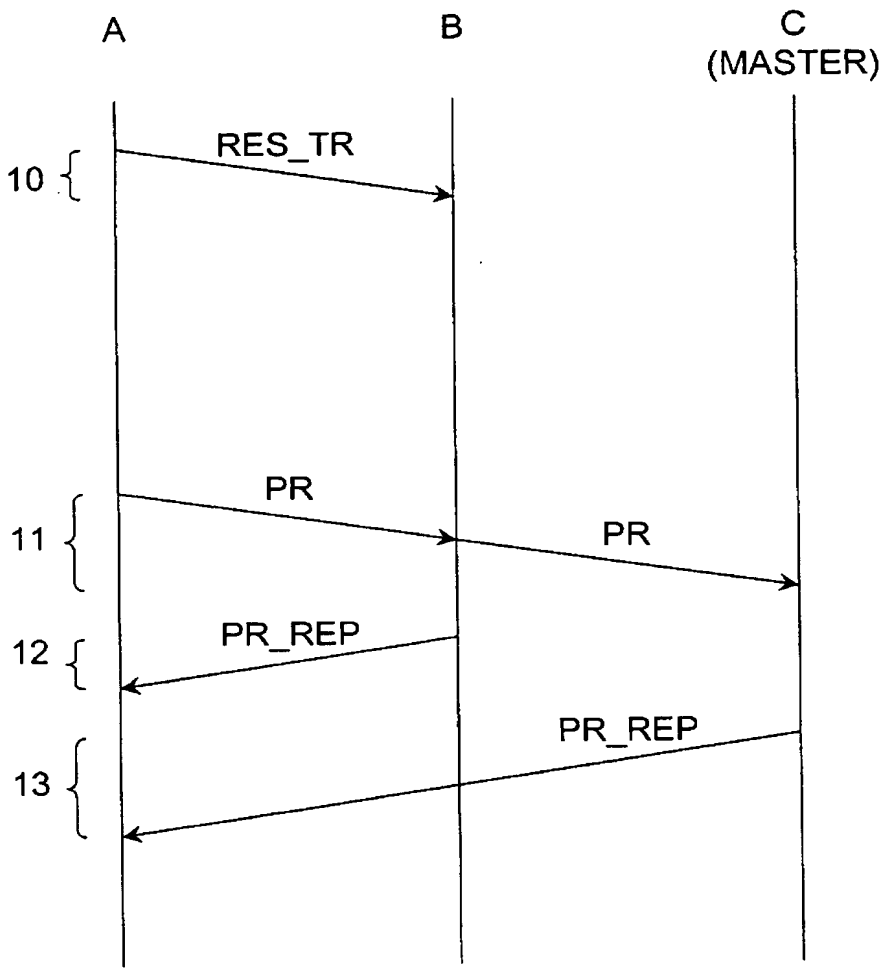
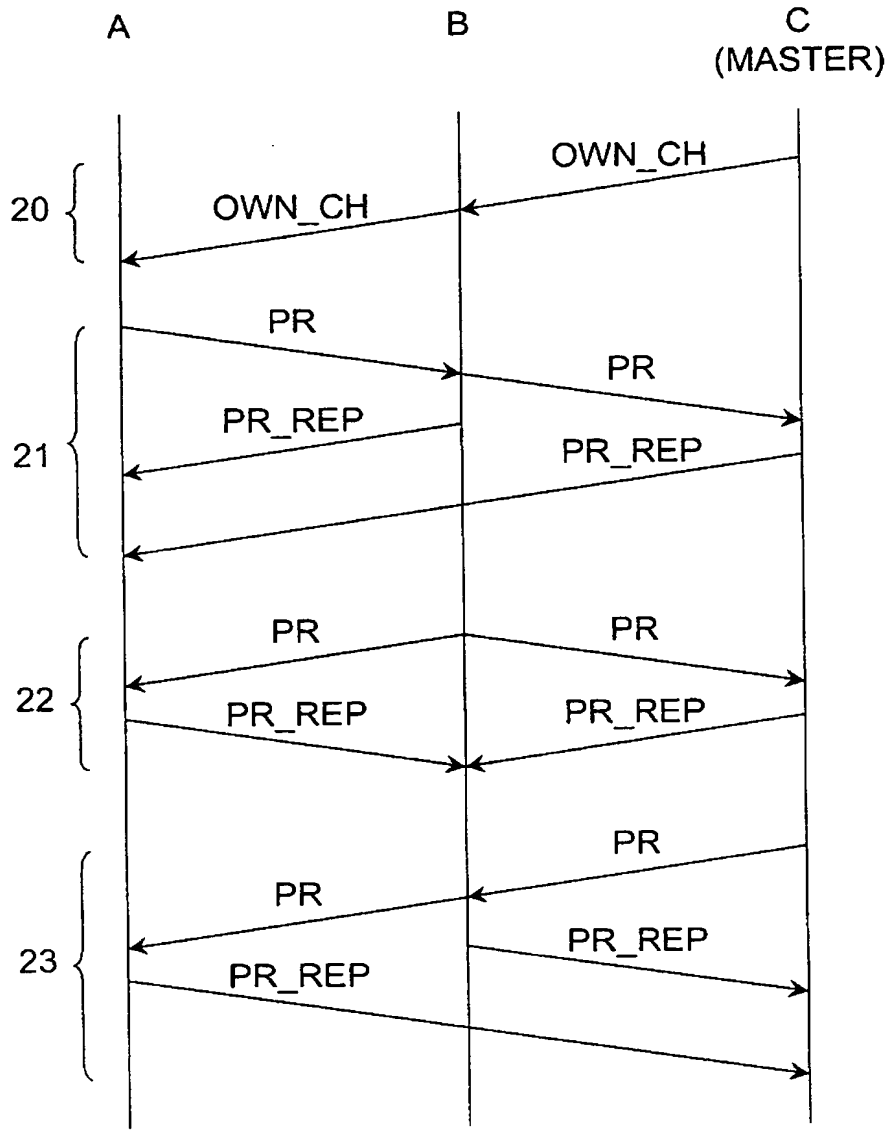


FIG. 2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PR
PR
PR_REP
PR_REP
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PR
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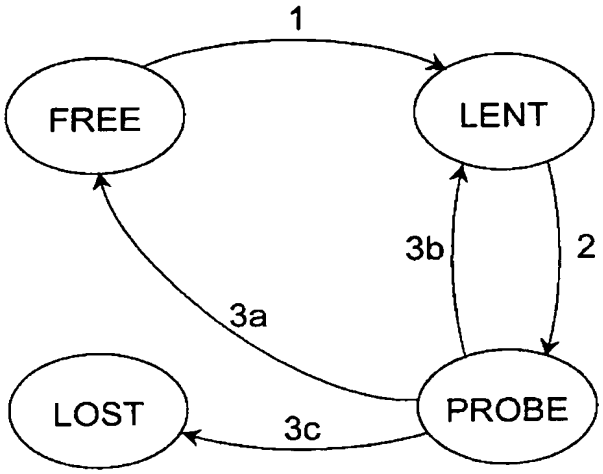
23
PR_REP

FIG. 3


1
FREE
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3b
2
3a
LOST
3c
PROBE

FIG. 4a

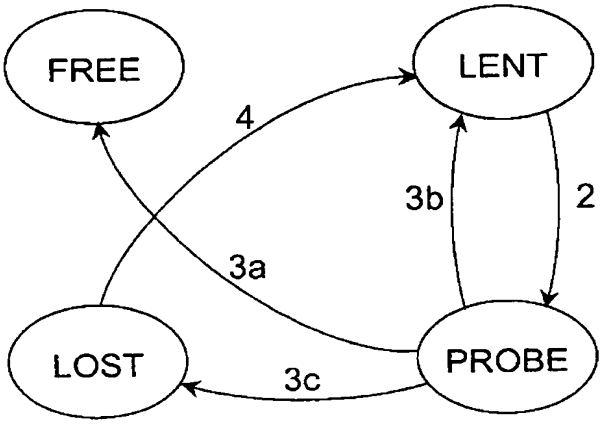
FREE
LENT
4
3b
2
3a
LOST
3c
PROBE

FIG. 4b

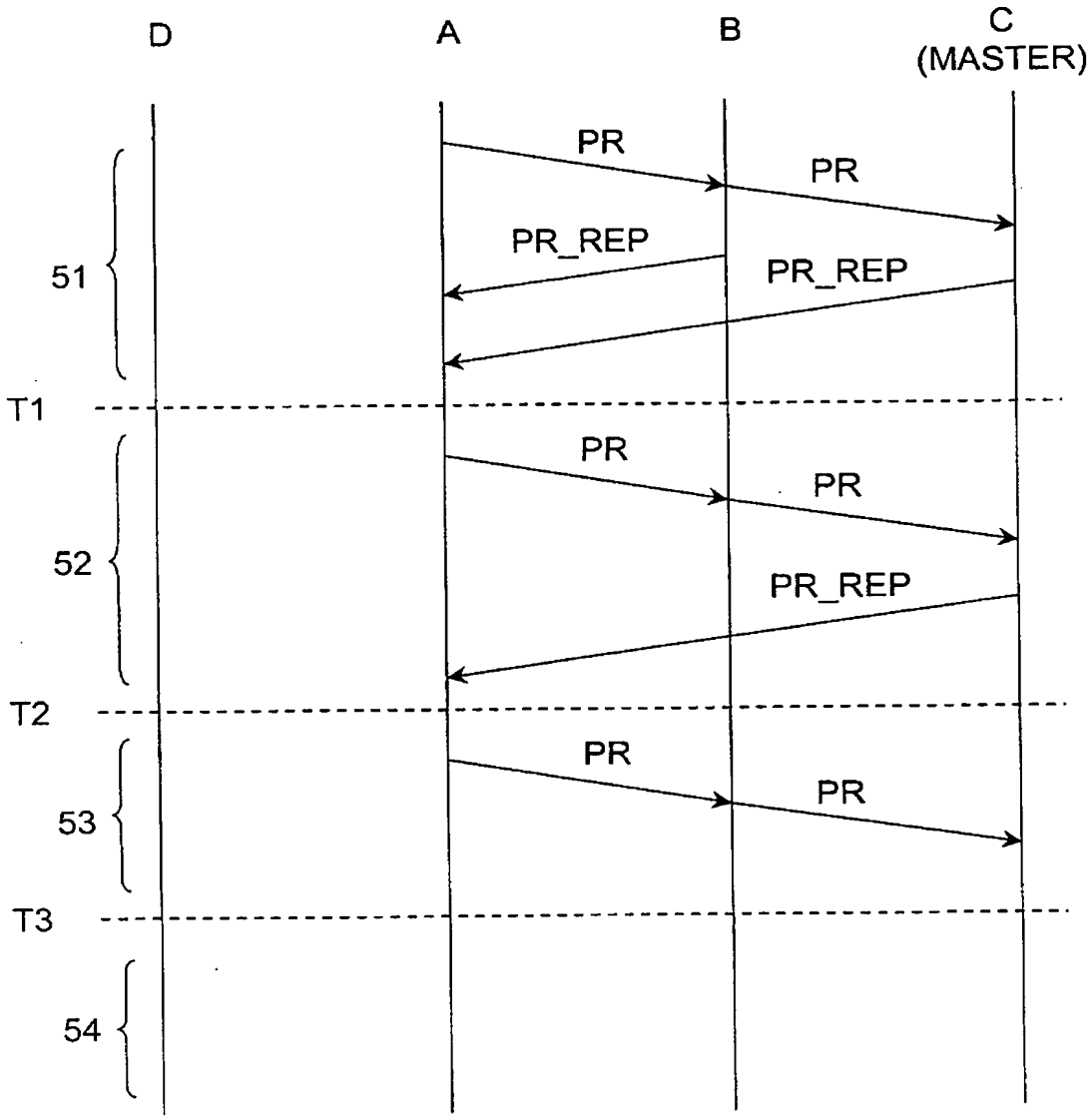
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FIG. 5

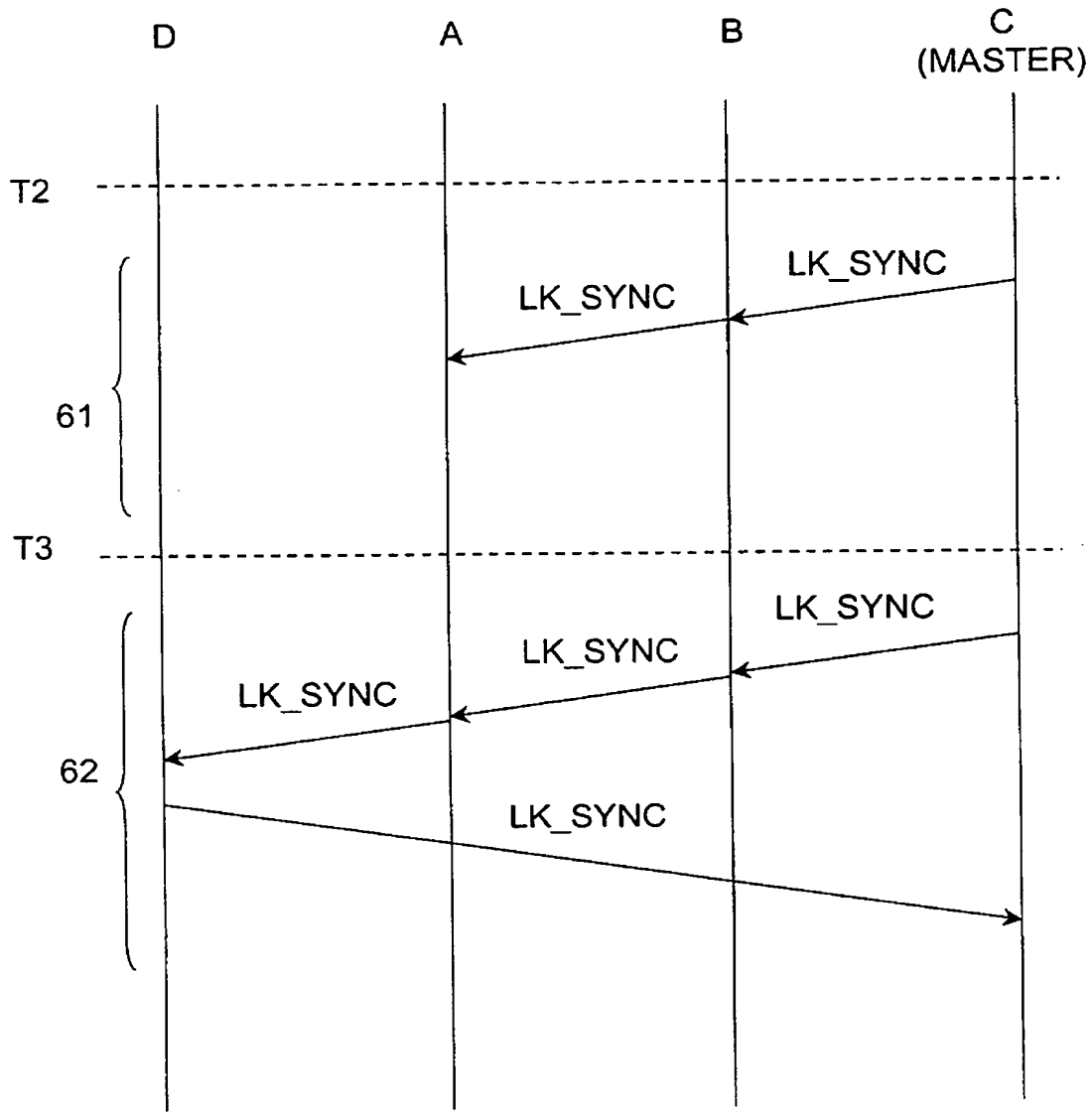

FIG. 6

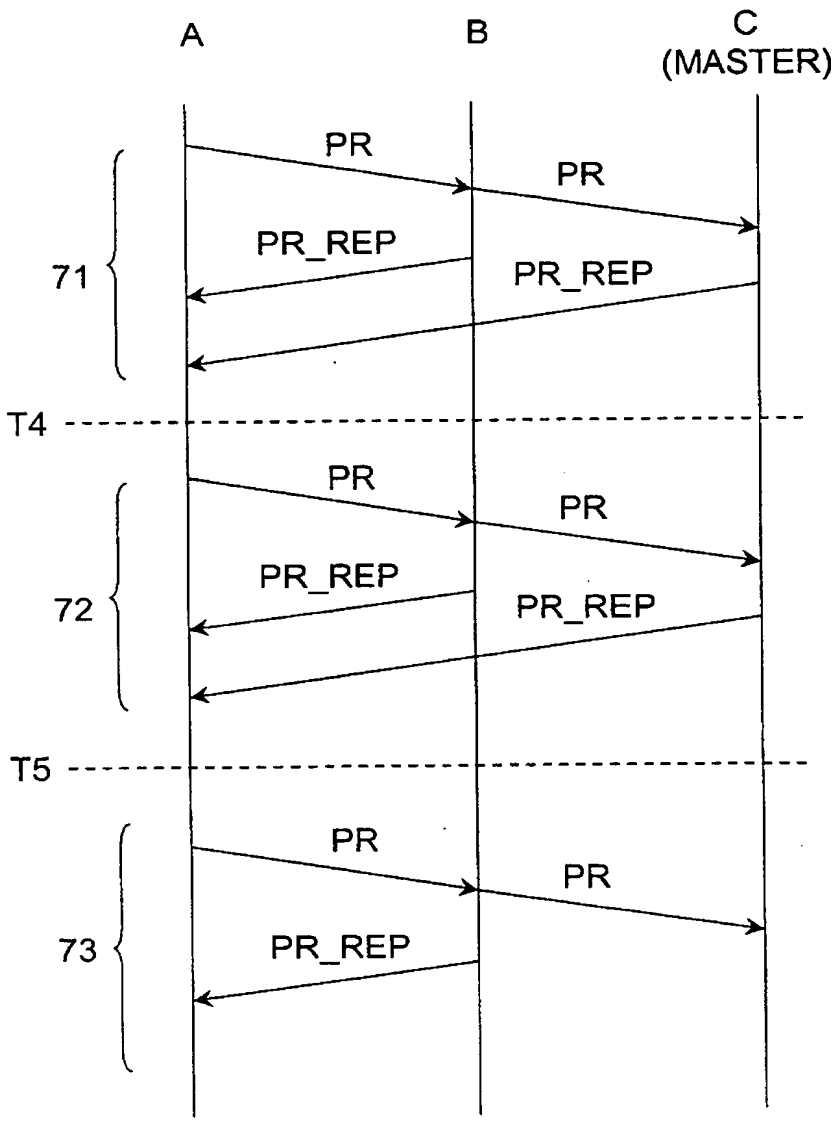

FIG. 7

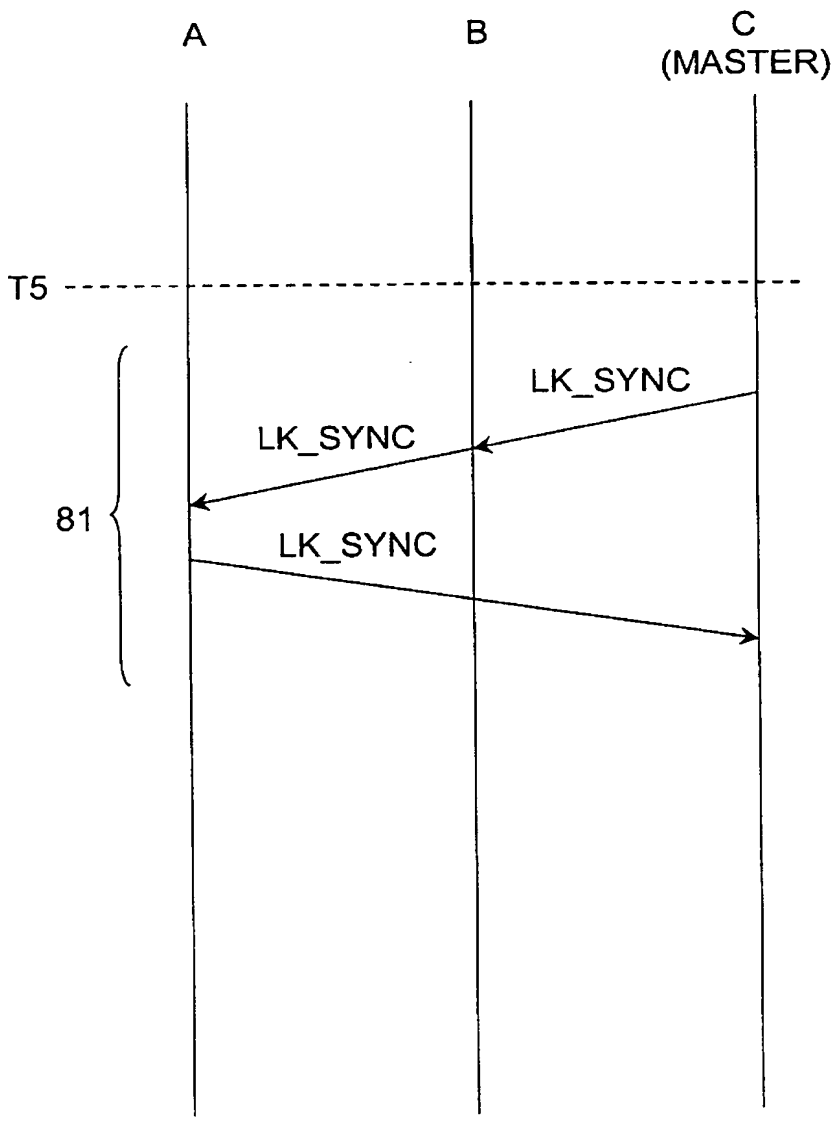

FIG. 8